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ARTHROXYLON, A REDEFINED GENUS OF CALAMITE*

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During the investigation of a specimen of a calamitean stem from an American coal field (described below) its relationship to *Arthrodendron* Scott 1899 (*Calamopitus* Will. 1871) was discovered. However, the name *Arthrodendron* may not be employed now, because, as will be shown, it is invalid in this sense.

In his first accounts of this material Williamson (1871, 1871a) was convinced of: (1) the calamitean affinity of the specimens; and (2) the fact that they differed structurally from other calamitean stems with cellular preservation that had been described. Accordingly, he called the specimens *Calamopitus*. But as for a binary name, he wrote: "I am disposed to regard all specific names and definitions as worthless. They separate things that I believe to be identical, and confound others that are obviously distinct" (1871). After some consideration of the different structural types of calamitean stems, that is *Calamodendron* Brong. 1849, *Arthropitys* Goepp. 1864, and *Calamopitus* Will. 1871, Williamson and Scott (1894) concluded: "We think . . . . *Calamopitus* should be retained. Besides the peculiar structure of its medullary rays it is characterized by the predominance of reticulated elements in its wood."

Sometime later Seward (1898) explained the substitution of the term *Arthrodendron* for *Calamopitus* thus: "Williamson's name *Calamopitys*[1] had previously been made use of by Unger for plants which do not belong to the Calamarieae. As it is convenient to have some term to apply to such stems as those which Williamson made the type of *Calamopitys*, the name *Arthrodendron* is suggested by my friend Dr. Scott as a substitute for Williamson's genus." Farther along, Seward 1898) recognized and elaborated on the three structural types, or "sub-genera" as he called them, yet while he mentioned various species of both *Calamodendron* and *Arthropitys* there was no binomial for *Arthrodendron*.

[1]Seward here uses the orthographic form.

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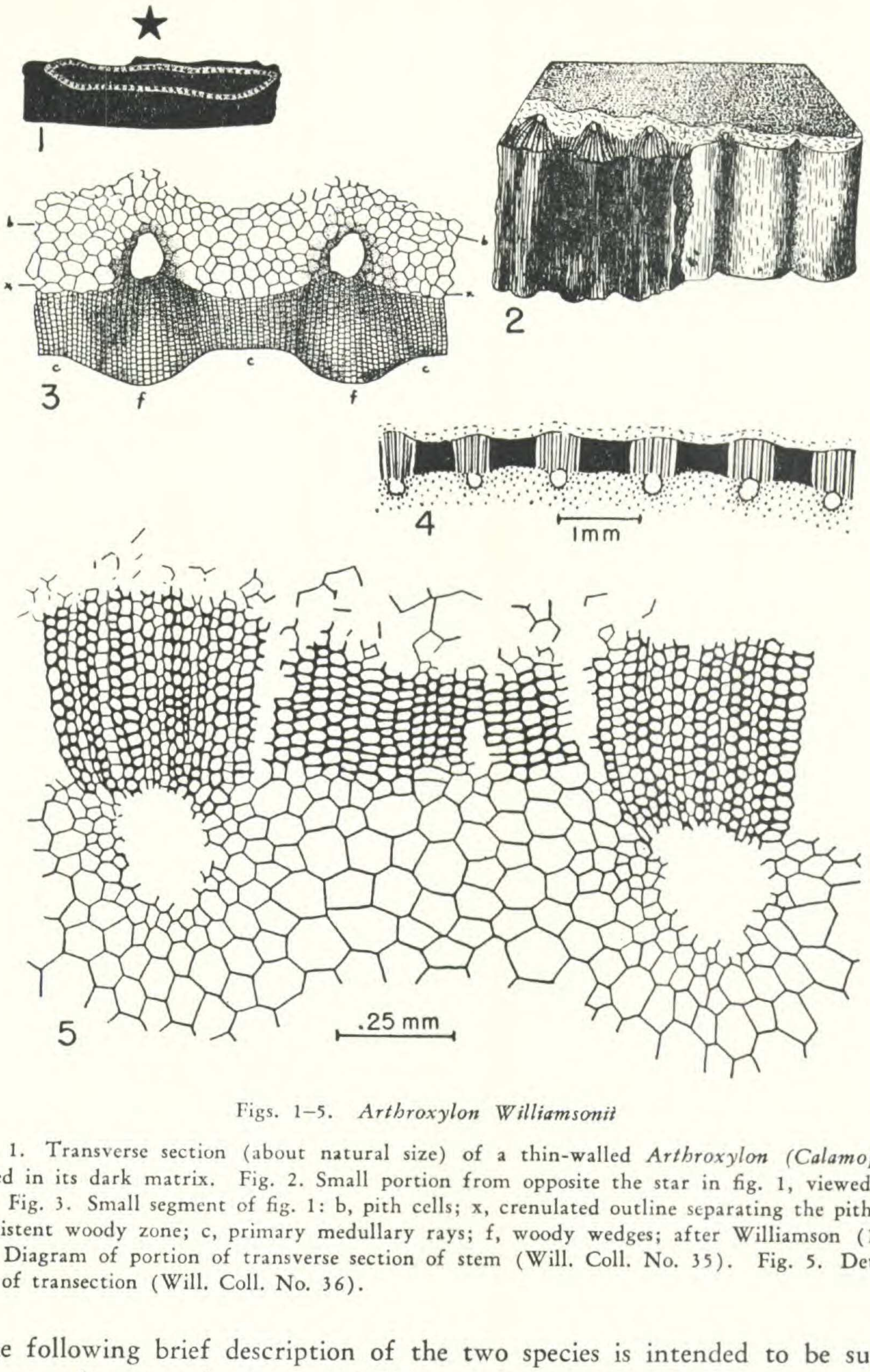
Since that time authors, as Zeiller (1900), Jongmans (1915), Leclercq (1925), Hirmer (1927), Hofmann (1934), Knoell (1935), Emberger (1944), and Arnold (1947) have employed Seward's terminology for calamitean stems with structure preserved. In the meantime, while the term *Arthrodendron* was dangling without a proper description or without having been typified, Ulrich (1910) described some fossil fucoid plants which were found near Kadiak, Alaska, to which he gave the name *Arthrodendron diffusum* gen. et sp. nov.

The term *Arthrodendron* seems more appropriate for a calamite than for an alga of uncertain affinity; also, it has been widely used in the former sense, for it is to be found in all the text-books of paleobotany. Nevertheless, there is no denying the valid priority of *Arthrodendron diffusum* Ulrich (1910), and therefore, I propose the name *Arthroxylon* for calamitean stems of this type.

Because of the historical significance and classical value, as well as the quality and quantity of the preparations of Williamson's specimens, it seemed appropriate that his material be redefined and given a binary name thereby making it the type material for *Arthroxylon*. In order to do so it was necessary to examine the preparations; hence, negotiations were completed with the British Museum of Natural History for the loan of the Williamson Collection of slides of calamites which he called *Calamopitus*. The collection received consisted of 21 preparations in two series, made from two different stems from different localities. In each series there are transverse and longitudinal—both radial and tangential—sections of the stems. Williamson described and figured these two calamitean stems in different articles (Williamson 1871, '71a); the stem of series 52–60 bears the earlier publication date.

A comparison of comparable or homologous sections of the two series, that is, transverse with transverse and tangential with tangential, leaves one with the impression that, although the two stems seem to be essentially similar in type and distribution of cells and tissues, they appear to be fundamentally quite different. As these stems also are patently of different ages, one having more than four times as much secondary wood as the other, the possibilities should be considered: (1) that their differences are more apparent than real because of disparity in age and size; (2) of their being stems of different orders, that is, primary or secondary axes from plants of the same species and consequently of a somewhat different structure; or (3), that the two stems actually are from different species. The first possibility may be rejected because of fundamental differences in cellular structure of the first formed and comparable secondary elements. As to their being stems of different orders—that remains a possibility, for as yet we do not know the range of structural variability of stems of different orders of the calamites so as to be able to say whether one is primary axis and another a lateral branch on the basis of isolated fragments. However, on the basis of primary structure it would seem most expedient, for the present at least, to recognize the two stem fragments as different species of *Arthroxylon*. The stem of series 35–46 is here designated *Arthroxylon Williamsonii*, and the other, series 52–60, *Arthroxylon oldhamium*.



Figs. 1–5. *Arthroxylon Williamsonii*

Fig. 1. Transverse section (about natural size) of a thin-walled *Arthroxylon (Calamopitus)*, imbedded in its dark matrix. Fig. 2. Small portion from opposite the star in fig. 1, viewed diagonally. Fig. 3. Small segment of fig. 1: b, pith cells; x, crenulated outline separating the pith from the persistent woody zone; c, primary medullary rays; f, woody wedges; after Williamson (1871). Fig. 4. Diagram of portion of transverse section of stem (Will. Coll. No. 35). Fig. 5. Detail of portion of transection (Will. Coll. No. 36).

The following brief description of the two species is intended to be supplementary to the original accounts (Williamson 1871, 1871a). While nine of the sections of series 35–46 and six of series 52–60 are longitudinal through nodal regions, yet because of the methods of preparation the orientation of the plane was more or less randomized. For accurate reconstruction of the node, carefully oriented serial cuts are necessary; hence, the sections at hand are inadequate for a detailed description of the nodal region. The nodal region unquestionably is important and may yet yield further diagnostic characters; moreover, it has not been ignored in the broader phases of this investigation. However, in the present report the internodal region is the only portion considered, since the great bulk of available preparations, or those made in the future, are likely to be of this region. Furthermore, the internodal region does provide diagnostic criteria, and attention is focused on those features which reveal characters thought to be specific in nature.

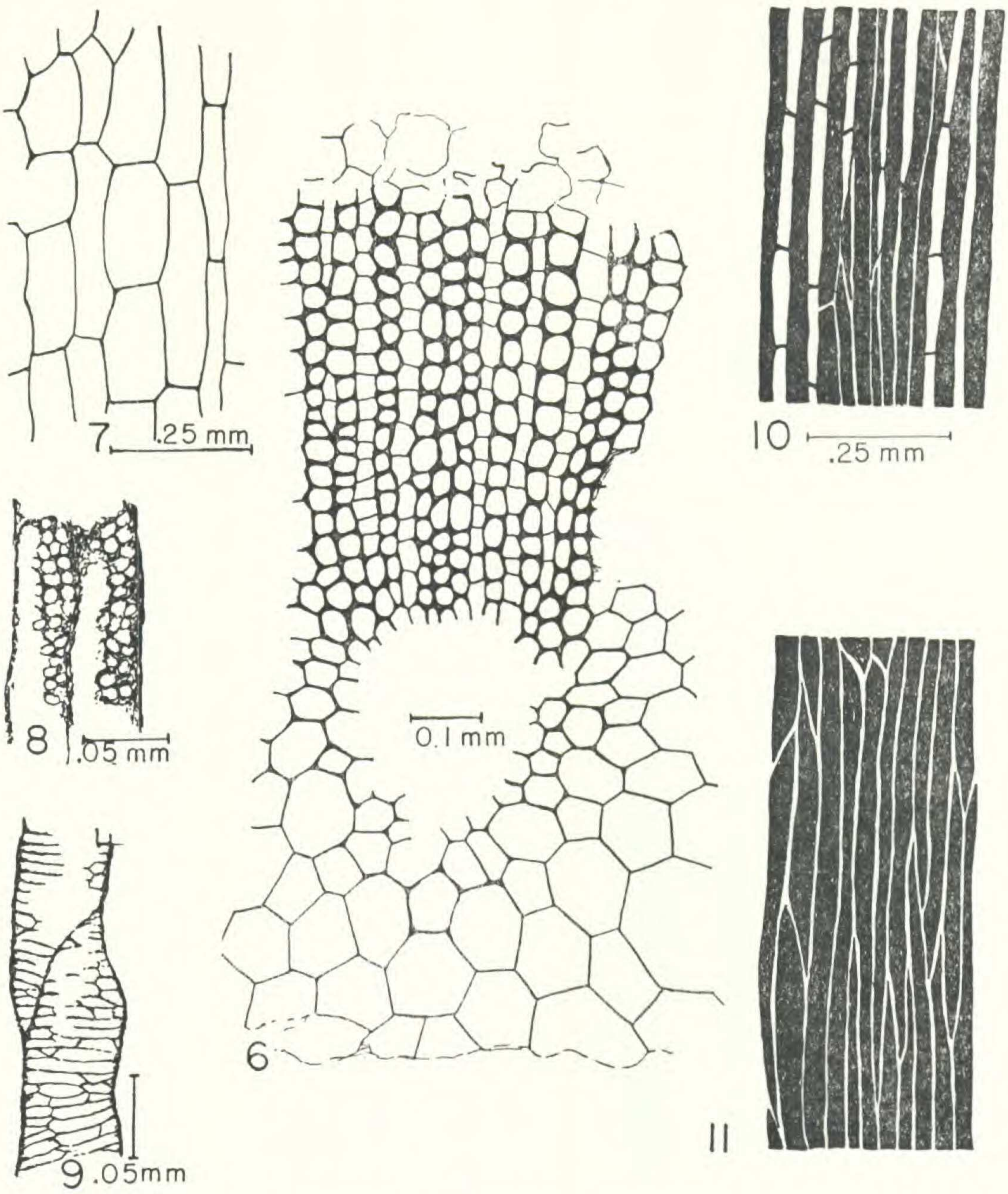
Arthroxylon Williamsonii

This account is based upon twelve preparations (Will. Coll. 35–46) made from a portion of a decorticated stem. Except for the title, "On the Organization of the fossil plants of the Coal-Measures" there is no information in Williamson's article (1871a) as to the origin of this particular specimen. He simply introduced it by saying: "I have next to call attention to a peculiar form identical in many respects with one that I described in the fourth volume of the third series of the Memoirs of the Literary and Philosophical Society of Manchester and to which I gave the generic name *Calamopitus*." The stem measured about 3 cm. in diameter; of this diameter the larger part by far is that of the fistular pith area, for the woody cylinder is only about 0.4 mm. thick (figs. 1, 2).

The thin-walled pith cells are sharply delimited from the secondary elements both in transverse and longitudinal views (figs. 3, 4, 5, 7). The carinal canals, conspicuous because of their relatively large size, appear to have been formed by the disintegration of both protoxylem and metaxylem. The exact number of canals was not determined, for neither of the transverse sections is entire; it was possible to count more than sixty, and the number probably would not exceed seventy. Williamson's figure 19 (fig. 1), which doubtless was made before the material was sectioned, shows 67 canals. Radiating from the canals are 14–17 rows, expanding to 18–20 at the periphery of the woody cylinder, of secondary conducting tissue averaging about 16 layers deep (figs. 4, 5, 6). These are composed of rows of tracheids with interspersed rows of parenchyma. There is some variation in the ratio of the number of rows of the former to the latter but it is usually two to one (figs. 5, 6). The rows of parenchyma—Williamson's "secondary rays"—are not easily distinguishable from the tracheids in transection, but in tangential section they stand out by virtue of their thinner walls and their lesser length (fig. 10).

The markings of the tracheids, which are scalariform to reticulated, are found chiefly, but not altogether, on the radial walls (figs. 8, 9).

The elements of the interfascicular secondary tissue—the "primary medullary ray" of Williamson—are organized in 16–18 radial rows (fig. 5), which are as regularly disposed as are the rows of the fascicular tissue. In transection the dimensions and thickness of the cell walls do not differ greatly from those of the tracheids. These features, that is, disposition, size, and thickness of the walls, combine to make the area appear extraordinarily like the fascicular area. However, upon closer observation some differences become apparent: (1) there is an



Figs. 6–11. *Arthroxylon Williamsonii*

Fig. 6. Detail of woody wedge (Will. Coll. No. 36). Fig. 7. Longitudinal section of portion of pith bordering canal—canal to the right (Will. Coll. No. 44). Fig. 8. Longitudinal radial walls of tracheids of X^2 (Will. Coll. No. 40). Fig. 9. Longitudinal walls of tracheids in vicinity of node (Will. Coll. No. 41). Fig. 10. Longitudinal tangential section of tracheids (shaded) and parenchyma (Will. Coll. No. 37). Fig. 11. Tangential longitudinal section through interfascicular area (Will. Coll. No. 37).

absence of rows of thin-walled parenchyma cells among the rows of thick-walled cells as were found among the rows of tracheids; and (2) in longitudinal section (fig. 11) the thick-walled cells are not only devoid of scalariform and reticulated markings but they are shorter than the tracheids and have a fusiform appearance. In short, these thick-walled fibrous cells appear to have been derived from fusiform cambial cells and to have matured without further elongation and without the development of specialized secondary thickenings as occurred in the maturation of the tracheids, or without subsequent transverse divisions of fusiform initials as in the formation of the wood parenchyma.

As is shown in figs. 5 and 6, there is some preservation exterior to the woody cylinder. The preservation of this region is so slight as to make description impossible; nevertheless, its presence does clearly show the limitation of the secondary wood.

Arthroxylon oldhamium

Although Williamson's description of the two specimens of *Arthroxylon oldhamium* appeared in 1871 it was not until much later (1896) that he wrote of their origin and their coming into his possession. His account is as follows:

> Early in the fifties when I was commencing in an unsystematic way to grind down fragments of various objects for microscopic investigations, I found in a drawer of my cabinet a portion of a Calamite that had been extracted from one of the ironstone nodules of the coal measures. I was not at that time provided with a lathe or any other sort of cutting or grinding machinery; but as the calamite presented indications that some structure might be found in it, I chipped off with hammer and chisel such fragments as appeared suitable, and ground them down on a flagstone, obtaining nine curious sections, showing the structure of a woody zone where it was in immediate contact with the medulla.
>
> Having then no intention of making any special use of these preparations, they were put away in a drawer of the cabinet and almost forgotten.
>
> About the same time I had instructed a working joiner to fit up for me a small horizontal grinding wheel, worked by a pedal, and which was not complete. Somehow this little transaction gave the joiner the idea that I was interested in stones; and one evening he called upon me, bringing in his apron a number of rough fragments of sandstone. He had been working at a stone quarry near Oldham, and had picked up from the refuse of the quarry a basketful of stones which appeared new to him, and he concluded that they might be interesting to me. They were in the main the merest rubbish, but amongst them I detected a fragment which was equally elegant and remarkable. How it had escaped destruction from the unprotected way in which it had travelled in such rough company was to me an absolute mystery. The specimen looked like the base of one calamite within the interior of a single joint of another and much larger one; but at that time I was wholly unable to construct any reasonable hypothesis explaining how the two parts had been brought into mutual relationship.
>
> In later days, when the specimen so oddly and accidentally obtained, came to be intelligently studied, its history became clear enough, and the priceless fragment is now one of the most precious gems in my cabinet. Some time after the occurrence of the above event Sir Charles Lyell happened to be at my home, and I showed him this specimen. He was much struck with its interest and novelty, and asked me to allow him to publish a figure of it in the fifth edition of his "Manual of Elementary Geology", upon the preparation of which he was engaged. Of course I consented, and the figure appeared in 1855 on page 368 of that work . . . .[2]

The "nine curious sections" referred to in the above quotation are the sections of Will. Coll. series 52–60. On these slides there are such small pieces of plant material that were it not for Williamson's figures (1871, fig. 2) showing its appearance before being sectioned, its calamitean affinity might be argued.

Preservation of this stem is limited to a very small portion of the secondary woody cylinder. Figure 12, a diagram from the better of the two transverse sec-

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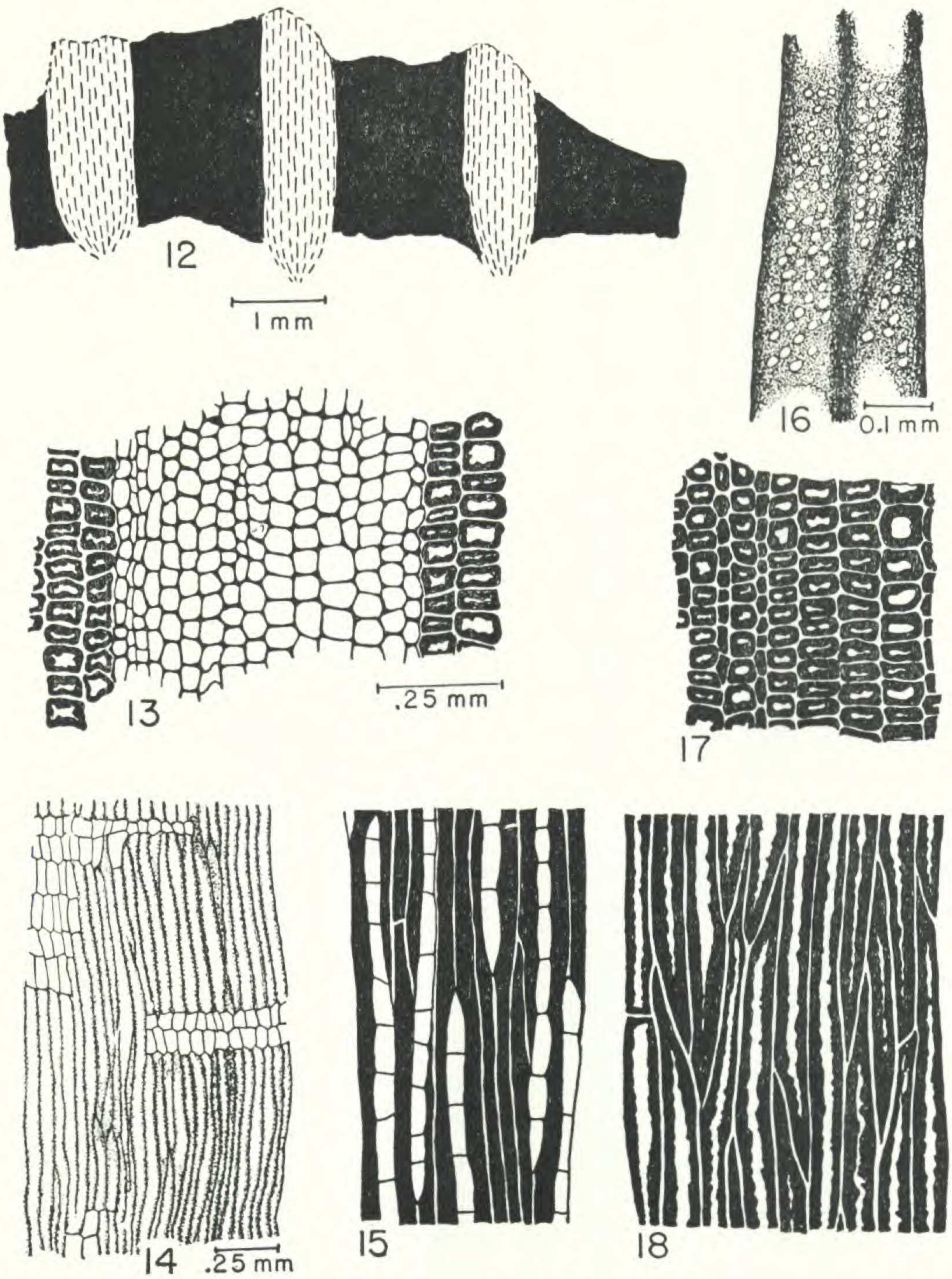
[2]The author wishes to express appreciation to Dr. H. N. Andrews for calling attention to the above quotation.



Figs. 12–18. *Arthroxylon oldhamium*

Fig. 12. Diagram of portion of transection of stem (Will. Coll. No. 52). Fig. 13. Detail of portion of fascicular wood bordered on either side by fibrous parenchyma (Will Coll. No. 52). Fig. 14. Longitudinal radial section through fascicular area (Will. Coll. No. 58). Fig. 15. Longitudinal tangential section through fascicular area (Will. Coll. No. 54). Fig. 16. Longitudinal radial walls of tracheids (Will. Coll. No. 58). Fig. 17. Transection of portion of interfascicular area (Will. Coll. No. 52). Fig. 18. Longitudinal tangential section through interfascicular area (Will. Coll. No. 54).

tions, shows the same pattern of rows of fascicular xylem alternating with rows of thick-walled fibrous cells as was found in the former species. It is in the cellular detail and in the proportion of tissues, rather than in tissue pattern, that *A. oldhamium* differs from *A. Williamsonii.*

In *A. oldhamium* there are fewer rows composing a fascicular xylem area; there had not occurred as many anticlinal divisions of tracheid and wood parenchyma initials to increase the number of rows, with the result that in transection the xylem bands maintain approximately the same width from the early formed secondary wood to the peripheral region, that is, in so far as the tissue of the woody cylinder is preserved (fig. 12). As in *A. Williamsonii*, these bands are composed of rows of tracheids interspersed with rows of parenchyma, although in transection the elements of the two are indistinguishable in size and thickness of their walls (fig. 13). But, again, as in *A. Williamsonii*, the tangential sections show the pattern of distribution of parenchyma and tracheids, except that in *A. oldhamium* the parenchyma cells are proportionately shorter than in *A. Williamsonii* (fig. 15). The relative length of the tracheids and parenchyma cells is also shown in radial section (fig. 14). Despite the quality of the preservation of the cells of this stem the markings on the walls of the tracheids remain elusive, particularly in the internodal region; occasional views, as that of fig. 16, show a kind of reticulated pitting on the radial walls.

The interfascicular area (fig. 12) is markedly different in appearance from the corresponding area of *A. Williamsonii*, yet structurally the areas are essentially alike. In *A. oldhamium* the area is considerably more extensive, being composed of 30–35 rows as compared with 16–18 rows as in the former species. The elements are larger in transection, their radial and tangential dimensions are about $42 \times 65\ \mu$; they are vertically elongated, their length varying from four to ten times their width, with tapering end walls (figs. 17, 18).

These regularly disposed elements of the interfascicular area are rendered more striking by the simulated thickness of their walls (figs. 13, 17, 18). In his description of this tissue, Williamson wrote: "Each cell appears to have thick walls, like those of recent woody fiber, which I at first believed these tissues to be; but I think that the appearance in question is due to mineral infiltration, and that the true walls were thin." This opinion has been confirmed by examining the sections with a polarizing microscope. Instead of being so extremely thick-walled that the lumen of the cells was almost occluded, as they appear in ordinary transmitted light (figs. 13, 17), these fibrous cells were found to have been selectively infiltrated by a turbid carbonate (calcite) of fibrous habit. The carbonate formed pseudo-spherulite aggregates which show undulose or plumose extinction upon rotation of the object stage of the microscope.[3]

Arthroxylon Williamsonii from an American coal field.—

This stem fragment was found in a coal ball collected by the late Professor A. C. Noé from a strip mine near Petersburg, Indiana. In the Ditney Folio (1902) the coal of this locality is listed as Coal No. 5 of the Upper Carboniferous.

The coal ball was a relatively small one with dimensions of approximately $5 \times 6 \times 7$ centimeters. Like most of these calcareous nodules, it contained an

[3]The author is indebted to Dr. J. C. Haff of the Geology Department of Mount Holyoke College for the polariscopic determination of the mineral content of the cells.

assemblage of diverse plant remains—diverse in the number of genera represented as well as in the organs and tissues. The identifiable plant fragments, in addition to the calamitean stem, were roots and leaves of *Sphenophyllum*, *Lepidodendron* leaves, *Stigmaria* rootlets, some specimens of *Lepidocarpon*, a bit of tissue from a *Medullosa* petiole, scattered fern sporangia, and some synangia.

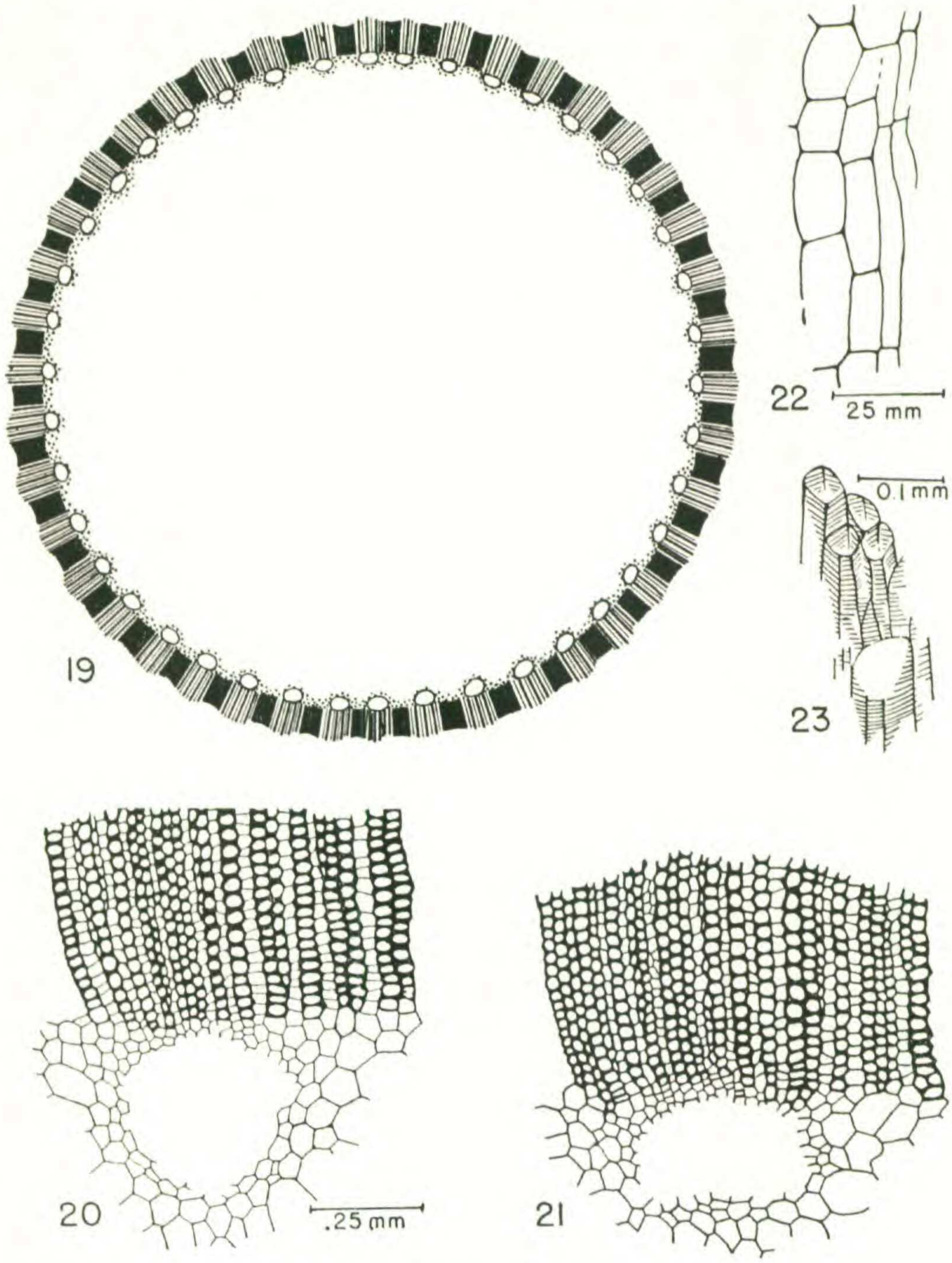
The following description of the specimen of *A. Williamsonii* is based upon 12 thin sections of the coal ball. They are labeled NR 1–12, and are deposited in the Museum of the Illinois State Geological Survey, Urbana, Illinois.

The calamitean material consisted of numerous pieces of wood which, while they were variously disposed and distributed throughout the width of the coal ball, seemed to lie in the same sedimentation plane. Also these pieces are comparable in structure and texture. Therefore, there seems but little doubt of their being parts of a stem that had been crushed and broken and the parts slightly separated before petrifaction. On this assumption all these woody fragments in section No. 5 were projected on paper, then the drawings were cut out and assembled in a ring; this assemblage provided the dimensions and proportions for the reconstruction shown in fig. 19. Preservation of the various tissues of this stem is far from complete, being limited to part of the pith, the elements of the woody cylinder, and occasional remnants of the cambium and phloem of the internodal region; also there seems to have been some chemical alteration of the cell walls which defaced the markings of the lignified cells, leaving the wall surface plain.

The Primary Tissues.—The thin-walled pith cells make a narrow peripheral zone which in transection rarely exceeds four cells deep (figs. 19, 20, 21). In transection the pith cells are roughly isodiametric; the innermost are the largest with an average diameter of about 80 μ, while the outer ones—those bordering the canal and the interfascicular secondary tissue—average about 30 μ in diameter. The cells are vertically elongated, the larger ones only slightly so, while the length of the smaller ones may exceed their width by ten or more times. All the pith cells have horizontal end walls (fig. 22).

There was a total of 42 carinal canals in the assembled pieces (fig. 19). Most of them seemed to have been formed by the complete breakdown of the primary xylem, yet in some instances, as in figs. 20, 21, 24, there are a few elements which, from their shape, position, and thickness of walls, seem to be of primary origin. In one longitudinal section there is a cluster of a few tracheids (fig. 23) which had been cut somewhat obliquely; because of their position near the border of the canal these, too, are thought to be primary xylem. These are the only tracheids in any of the preparations, either longitudinal or transverse, with markings clearly visible; here they are seen as scalariform thickenings on all longitudinal walls.

The carinal canals vary somewhat in shape (figs. 20, 21) but are essentially round in transection with an average diameter of about 350 μ. In comparison with the size of the adjacent pith cells and those of the secondary xylem the canals are larger than in any specimen of calamite I have yet encountered.



Figs 19–23. *Arthroxylon Williamsonii*

Fig. 19. Diagram of reconstruction of transverse section of stem (NR. #4). Figs. 20 and 21. Details of two of carinal canals with pith and radiating secondary elements (NR. #5). Fig. 22. Longitudinal section of portion of pith bordering canal—canal at right (NR. #10). Fig. 23. Cluster of tracheids thought to be primary in origin (NR. #7).

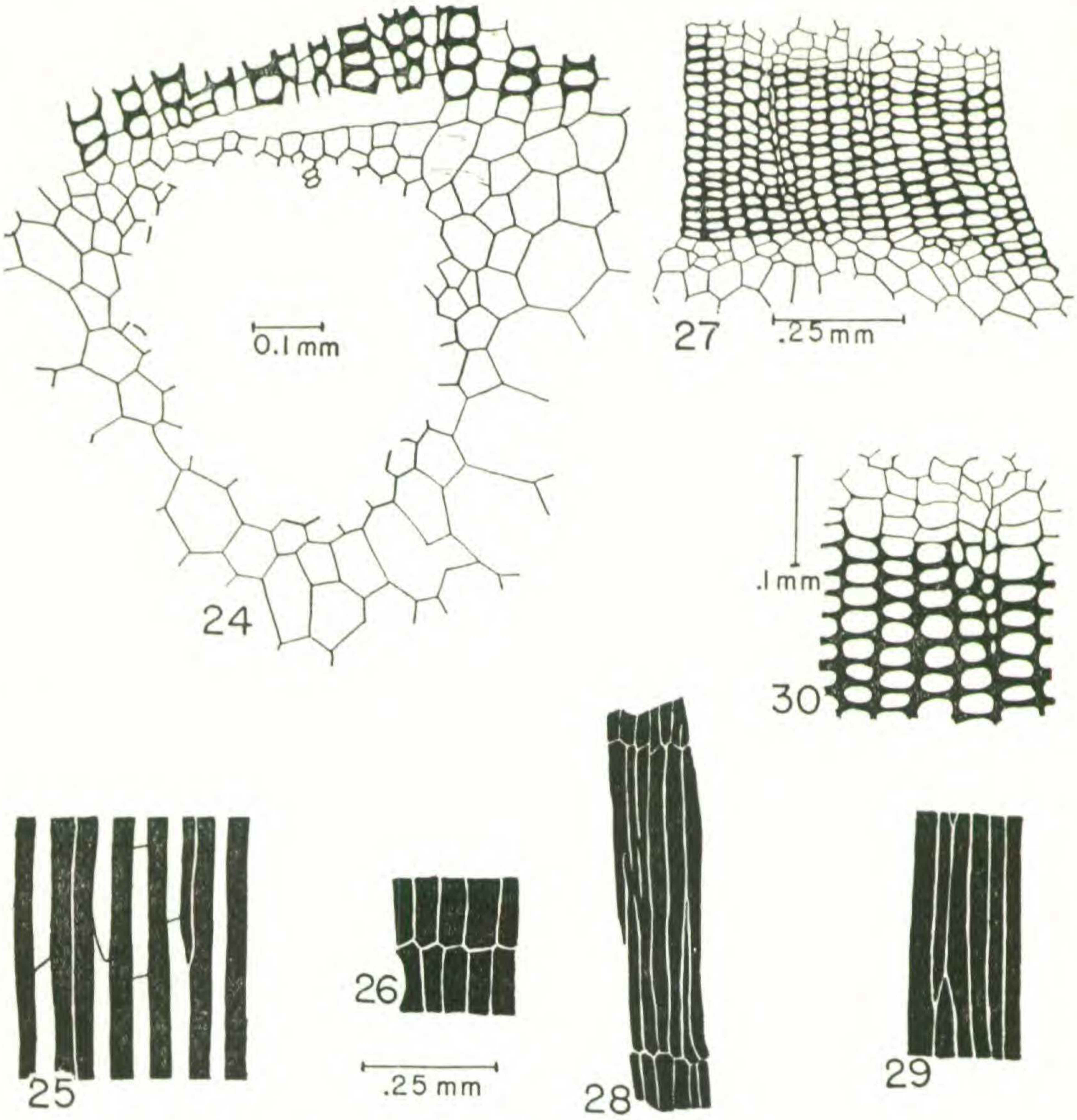
The Secondary Tissues.—In this stem there appears to have been a continuous layer of stelar cambium initiating the secondary tissues, as they form a complete cylinder at the inner margin (figs. 19, 20, 21). Furthermore, the cells are so nearly the same size that under low magnification (32-mm. objective) the transection of the secondary system gives the impression of being a uniform circular band of simple construction with a crenulated outer margin. Yet, when examined under high magnification these tissues resolve into a more complicated pattern. The band of secondary tissues consists of 18–24 layers of cells, the number depending somewhat on the degree of preservation, organized in alternating groups of conducting elements and thick-walled fibrous elements (fig. 19).

Each group of conducting tissue is composed of 14–16 rows of secondary elements radiating centrifugally from the carinal canal; approximately one-third of these are uniseriate rows of thin-walled parenchyma cells which alternate with one to three or even four rows of thick-walled tracheids (figs. 20, 21, 24). In transection the two types of cells, that is, those of the tracheids and parenchyma, are not so different in size or shape, both being squarish with average dimensions of about $25 \times 25\ \mu$, but are to be discriminated chiefly by the difference in the thickness of their walls. However, in tangential section the parenchyma, or "rays" as termed by Williamson, stand out not only because the walls are thinner but also because they are shorter. The available sections scarcely exceed a millimeter in length but in all the end walls were to be found in the parenchyma cells, and there were some instances, as in fig. 25, where both extremities of a cell were found in one field. Occasional end walls of tracheids were encountered, as shown in figs. 25 and 26, but tracheid length was not determined as it was greater than that of the sectioned material.

As the secondary elements were being formed there occurred at intervals anticlinal divisions which increased the number of rows to 28–30 at the outer limit of the woody cylinder. Usually the anticlinal divisions were confined to tracheid initials (figs. 20, 21).

Alternating with the conducting tissue (in transection) are bands of fibrous cells of secondary origin arranged in 18–20 radial rows (figs. 19, 27). There are about as many cells in a row as are found in a row of the conducting region, but the radial diameter of the individual cells is less than that of the tracheids, hence the rows are shorter with consequent decrease in the width of this band of tissue as compared with that of the conducting tissue. It is this difference in width of the two types of tissue that is largely responsible for the fluted exterior of the woody cylinder.

Except for the slight difference in shape of the cells composing it this fibrous tissue bears a striking resemblance, in transection, to the conducting tissue; the cells have thick walls, have an average radial diameter of about $22\ \mu$, and a tangential diameter of $37\ \mu$, and were laid down with the same regularity. Yet, as in the former specimen of *A. Williamsonii* and in *A. oldhamium,* closer observation reveals two differences: (1) there is an absence of the thin-walled uniseriate parenchymatous rows; and (2) there had been fewer anticlinal divisions to increase the number of rows, so that this band of tissue remains essentially the same width from its origin at the pith to the peripheral region of the secondary activity (fig. 27). These differences which are noted in transection are verified by longisection.



Figs. 24–30. *Arthroxylon Williamsonii*

Fig. 24. Detail of cells about the carinal canal (NR. No. 5). Fig. 25. Longitudinal tangential section through the fascicular area (NR. No. 6). Fig. 26. Longitudinal radial section through the fascicular area (NR. No. 11). Fig. 27. Transverse section through the interfascicular area (NR. No. 5). Fig. 28. Longitudinal radial section through fibers (NR. No. 6). Fig. 29. Longitudinal tangential section of fibers (NR. No. 9). Fig. 30. Detail of portion of transection of interfascicular area showing cambium (NR. No. 5).

Figures 28 and 29 are longitudinal (radial and tangential) views of these cells; they are vertically elongated, their length being many times their width, with end walls acutely oblique in tangential view. Their walls all appear to be of uniform thickness with no discernible markings. This tissue, therefore, manifests the same homogeneity of its elements and their organization as was found in the comparable area of the two specimens of *Arthroxylon* from the British Coal Measures.

The meager amount of cambium and phloem preserved, of which fig. 30 shows one of the rare instances, would not be worth recording were it not for the fact that it demonstrates the limit of the activity of the stelar cambium.

Some General Considerations and Key.—

In his account of the types of calamitean stems with structure preserved Scott (1920) wrote of *Arthroxylon (Arthrodendron)*: "The *Arthrodendron* type of stem is a rare one. The wood, in the specimens known, is of no great thickness, and the primary bundles are widely separated by primary medullary rays. The chief peculiarity is in the structure of the rays, which are formed, for the most part, of vertically elongated prosenchymatous cells, thus differing widely from the usual parenchymatous structure of these organs." The calamitean stem from an American coal field, described above, shares these generic characters with specimens of *Arthroxylon Williamsonii* and *A. oldhamium* from the British Coal-Measures.

Because of the disparity of geographic origin it seemed possible that the specimen from Indiana would fall into a third species. However, the size and proportion of tissues and the dimension and organization of cells of the material at hand are so markedly like the type of *A. Williamsonii* that the two key down to the same species.

As for *Arthroxylon* being a "rare type"—one can not help wondering whether a reinvestigation of some of the calamitean stems that have been otherwise labeled might not reveal them to be *Arthroxylon.* In transection (many descriptions have been made from transection only) the bands of fibrous parenchyma cells are almost indistinguishable from conducting tissue unless, as in the specimen of *A. oldhamium,* there had been a selective infiltration of mineral which sharply demonstrated a difference of structure of the cells and differentiated and delimited the two tissues. It seems probable, therefore, that in some cases the fibrous tissue in question has been interpreted as interfascicular xylem.

The question might well arise as to why in the present study no use has been made of the character of the wood stressed by Williamson and Scott (1894). According to them, the wood of *Arthroxylon (Calamopitus)* was "characterized by the predominance of reticulated elements in its wood." However, it is my opinion that one might easily overemphasize this character. These specimens do show, as was noted by Williamson and Scott, scalariform pitting of the primary wood (fig. 23), scalariform to reticulated pitting in the tracheids of the nodal region (fig. 9), and reticulated pitting in the secondary wood (figs. 8, 16). Yet the type of reticulation (pit) may well depend on the differential amount of erosion of the border prior to preservation. Therefore, until more is known of the type of reticulation, that is, of the pit types in calamitean secondary wood, it has been thought best not to stress this feature in the present key and diagnosis.

KEY TO GENERA OF CALAMITE STEMS WITH STRUCTURE PRESERVED, AND TO SPECIES OF *ARTHROXYLON**

1. Secondary interfascicular area composed of parenchyma and tracheids.... *Arthropitys*
1. Secondary interfascicular area composed of parenchyma only.
   2. Interfascicular parenchyma composed of alternating radial bands of thick- and thin-walled cells.......... *Calamodendron*
   2. Interfascicular parenchyma composed of essentially similar cells... .... *Arthroxylon*
      a. Interfascicular area of 16–18 rows; radial and tangential diameter of elements 26 × 34 μ.......... *A. Williamsonii*
      a. Interfascicular area of 30–35 rows; radial and tangential diameter of elements 42 × 65 μ.......... *A. oldhamium*

* Based on transection of the internodal region.

Arthroxylon Reed, nom. nov.[4]

Calamopitus Williamson, Mem. Manchester Lit. and Phil. Soc. III, 4:174, figs. 1–17. 1871. (Without type; no species indicated or described).
Calamopitys Seward, Fossil Plants 1:301. 1898. (Without species). Not *Calamopitys* Unger, Denkschr. K. Akad. d. Wiss. Wien. 1:159. 1856.
Arthrodendron Scott, in Seward, Fossil Plants 1:301. 1898. (As subgenus; without type; no species indicated or described). Not *Arthrodendron* Ulrich, Harriman Alaska Series (Smithson. Inst.) 4:138, pl. XIV, figs. 1–3. 1910.

Calamitean stem with internodal region of stele organized in alternating bands (as viewed in transection) of conducting tissue and fibrous parenchyma. Bands of parenchyma as wide or wider than the bands of conducting tissue, composed of fusiform cells with walls as thick as those of the tracheids.

Arthroxylon Williamsonii Reed, sp. nov.

Stems with about 70 large carinal canals (diameter up to 360 μ). Secondary conducting tissue composed of 14–17 rows of tracheids with interspersed rows of parenchyma radiating centrifugally from the carinal canal; the number of rows gradually increased by anticlinal divisions of tracheid initials. Both tracheids and parenchyma roughly squarish in transection with an average dimension of about 22 μ. Bands of fusiform parenchyma cells organized in 18–20 radiating rows, cells with an average radial diameter of 26 μ and tangential diameter of 34 μ.

Horizon: British Coal-Measures; American Upper Carboniferous.

Material: Twelve thin sections (Williamson Collection 35–46) in Geology Department of the British Museum of Natural History; 12 sections (NR 1–12) in the Museum of the Illinois State Geological Survey, Urbana, Illinois.

Type: Williamson Collection No. 35.

Arthroxylon oldhamium Reed, sp. nov.

Secondary conducting tissue composed of 8–10 rows of tracheids with interspersed rows of parenchyma. Very few anticlinal divisions, with the result that the bands of tissue remain virtually the same width from the inner limit at the carinal canal to the peripheral region. Tracheids and parenchyma cells roughly squarish in transection with average dimensions of 44 μ. Bands of fusiform

[4] The generic name is derived from Αρθρον—articulated, and Ζυλον—wood.

parenchyma organized in 30–36 radial rows; cells with average radial diameter of 42 μ and tangential diameter of 65 μ.

Locality and horizon: Sandstone-Quarry near Oldham, British Coal-Measures.

Material: Nine sections (Williamson Collection Nos. 52–60) in the British Museum of Natural History, London.

Type: Williamson Collection No. 52.

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